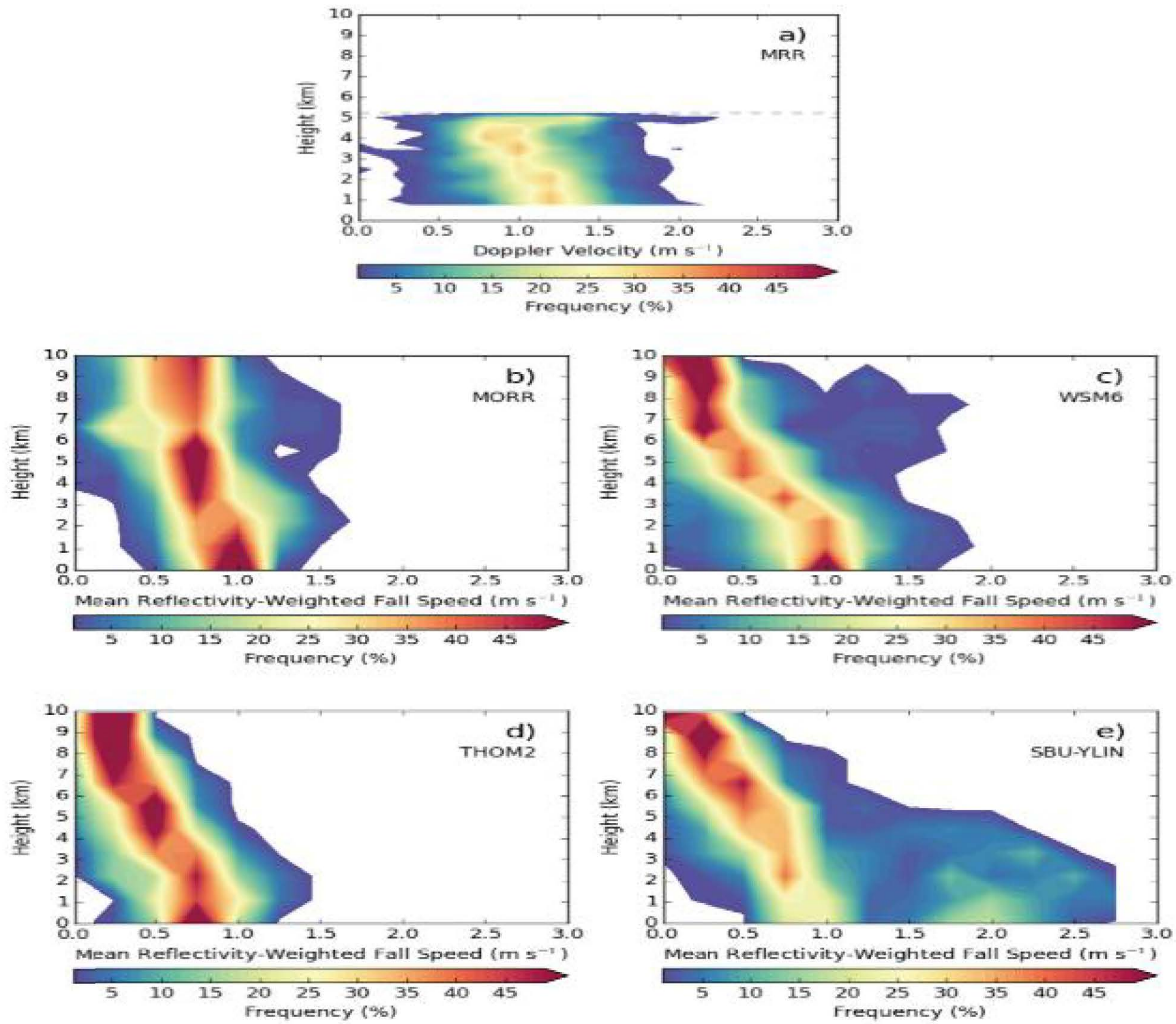
Stony Brook University
School of Marine and
Atmospheric Sciences

SPORT

THE UNIVERSITY OF
ALABAMA IN HUNTSVILLE

Motivation

- Increasing evidence that bulk microphysical schemes in mesoscale models underpredict riming within winter storms.



Simulations of nine winter storms over Long Island, NY highlighted underprediction of snow fallspeeds during moderate riming conditions as compared to MRR measurements

Moltham et al. (2016)

Some Questions

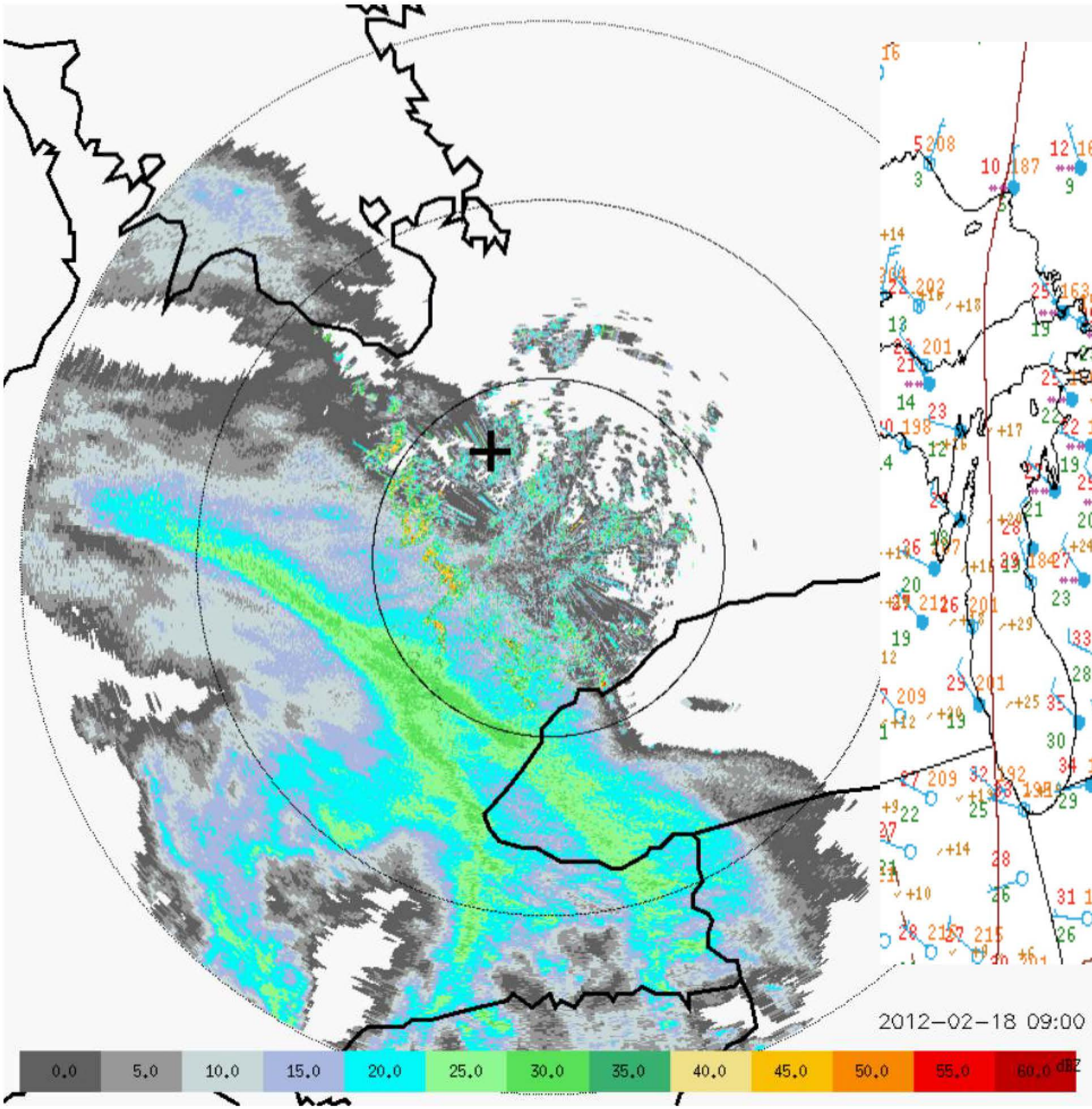
- What processes led to the rapid intensification and microphysical changes of the warm frontal precipitation band (Colle et al. 2016)?

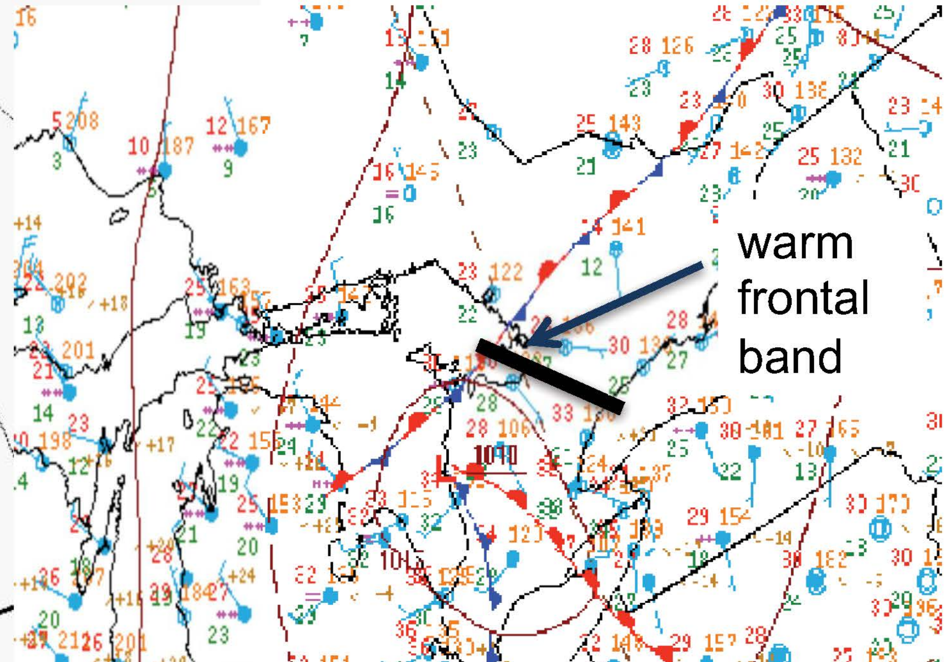
- How well can current, more advanced BMPs (i.e, P3, Goddard 4ICE, SBU, and Morrison) predict the warm frontal band development and riming intensity for this event?

- How do cloud microphysical processes modify the environmental conditions and the subsequent warm frontal band development?

Warm Frontal Band During GCPEx

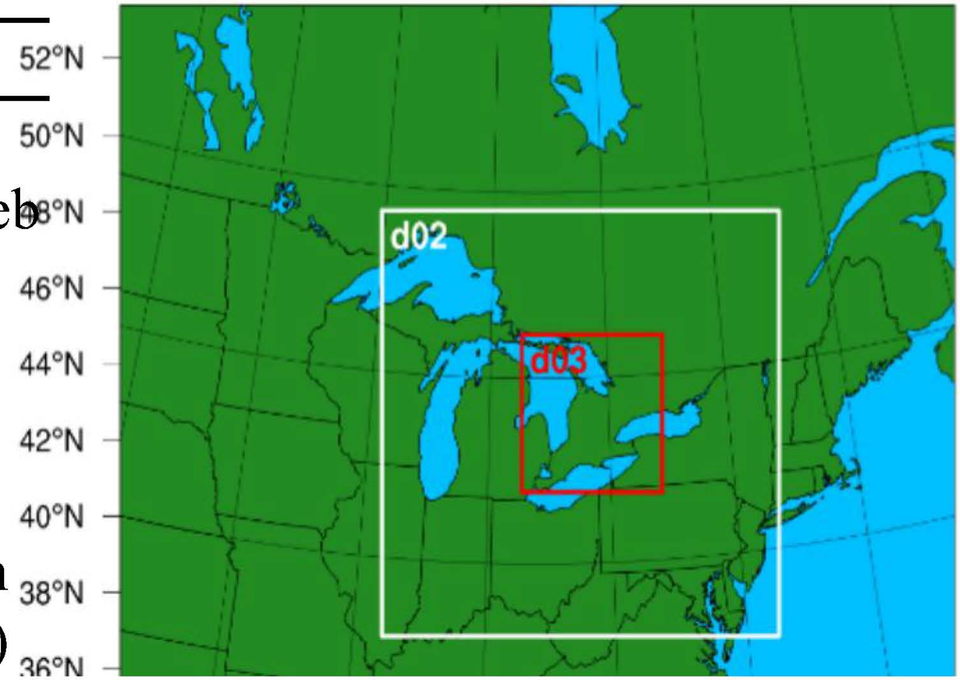
18 February 2012: King City Radar Animation   1200 UTC NWS Surface Analysis

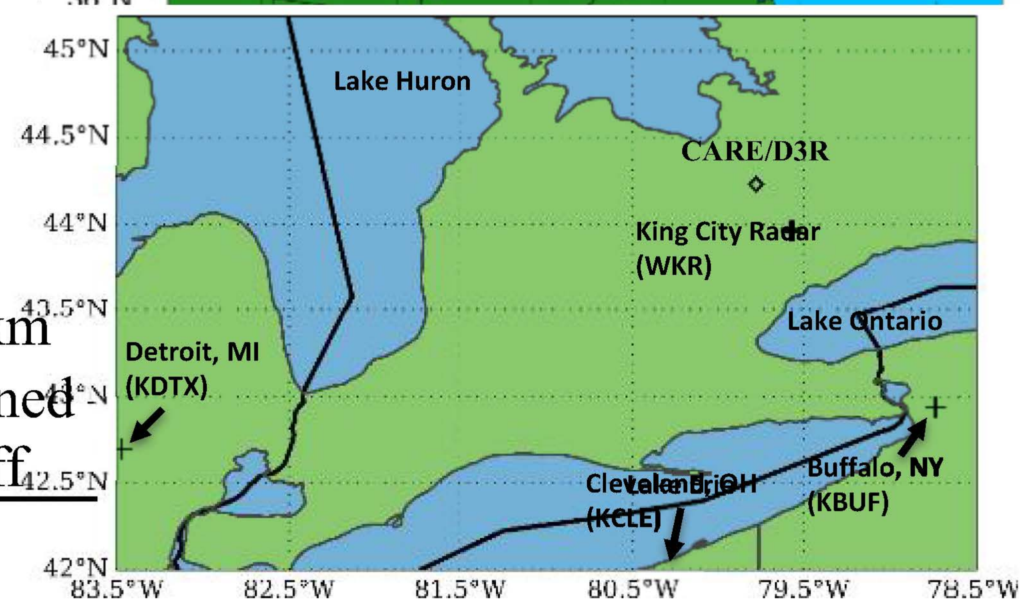


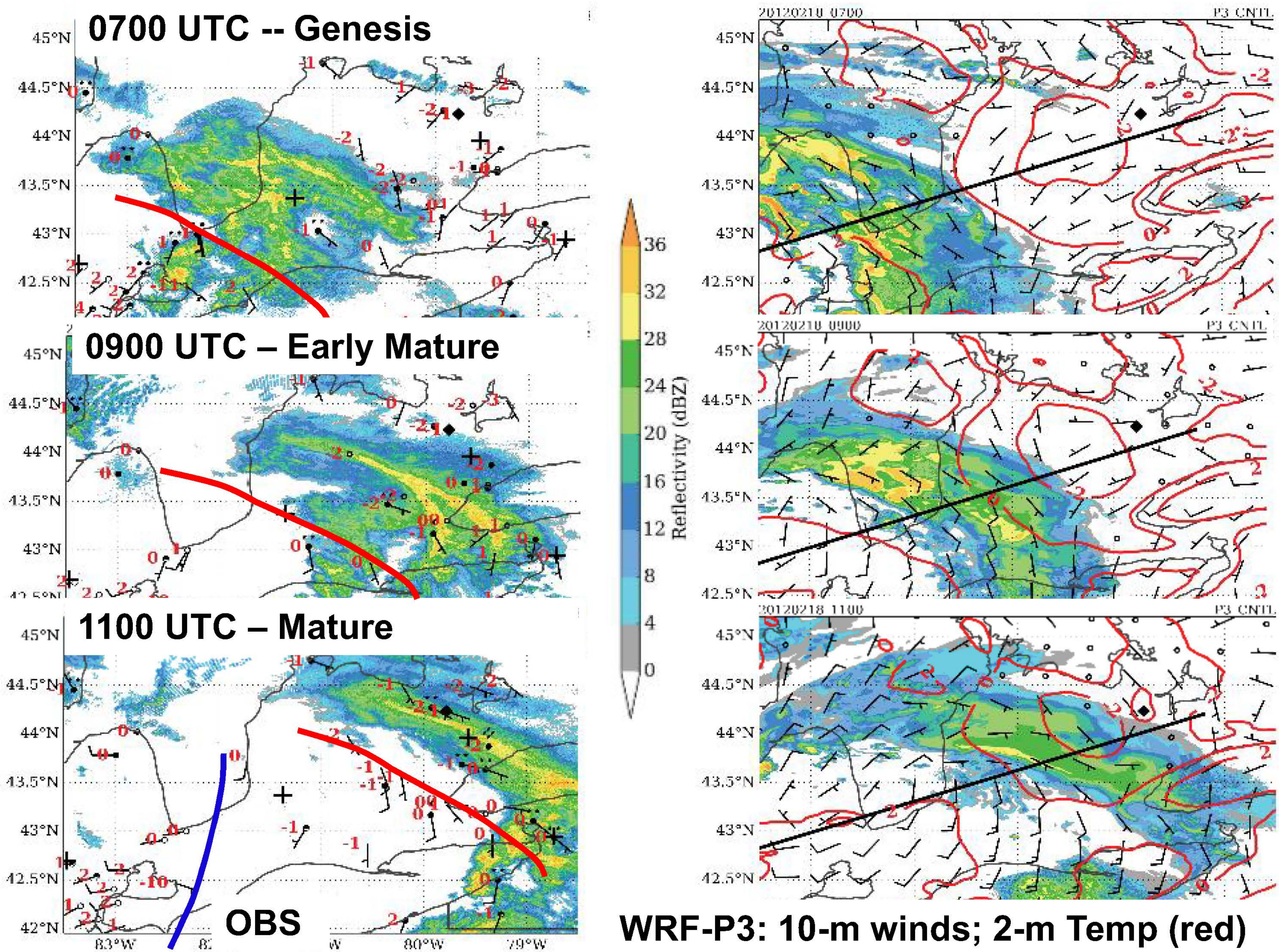


Weather Research and Forecasting Simulations

NASA-Unified-WRF configuration			
IC and Boundary Conditions	6-h RUC Analyses starting 1800 UTC 17 Feb (30-h run)		
Vertical Resolution	50 Levels		
PBL Physics	Mellor-Yamada-Janjic		
Cloud microphysics	P3 scheme for CTL run (Morrison et al. (2015)		
Short- and Longwave Radiation	RRTMG		
Horizonal Resolution	9 km	3 km	1 km
Cumulus scheme	Grell-Freitas	Turned off	Turned off





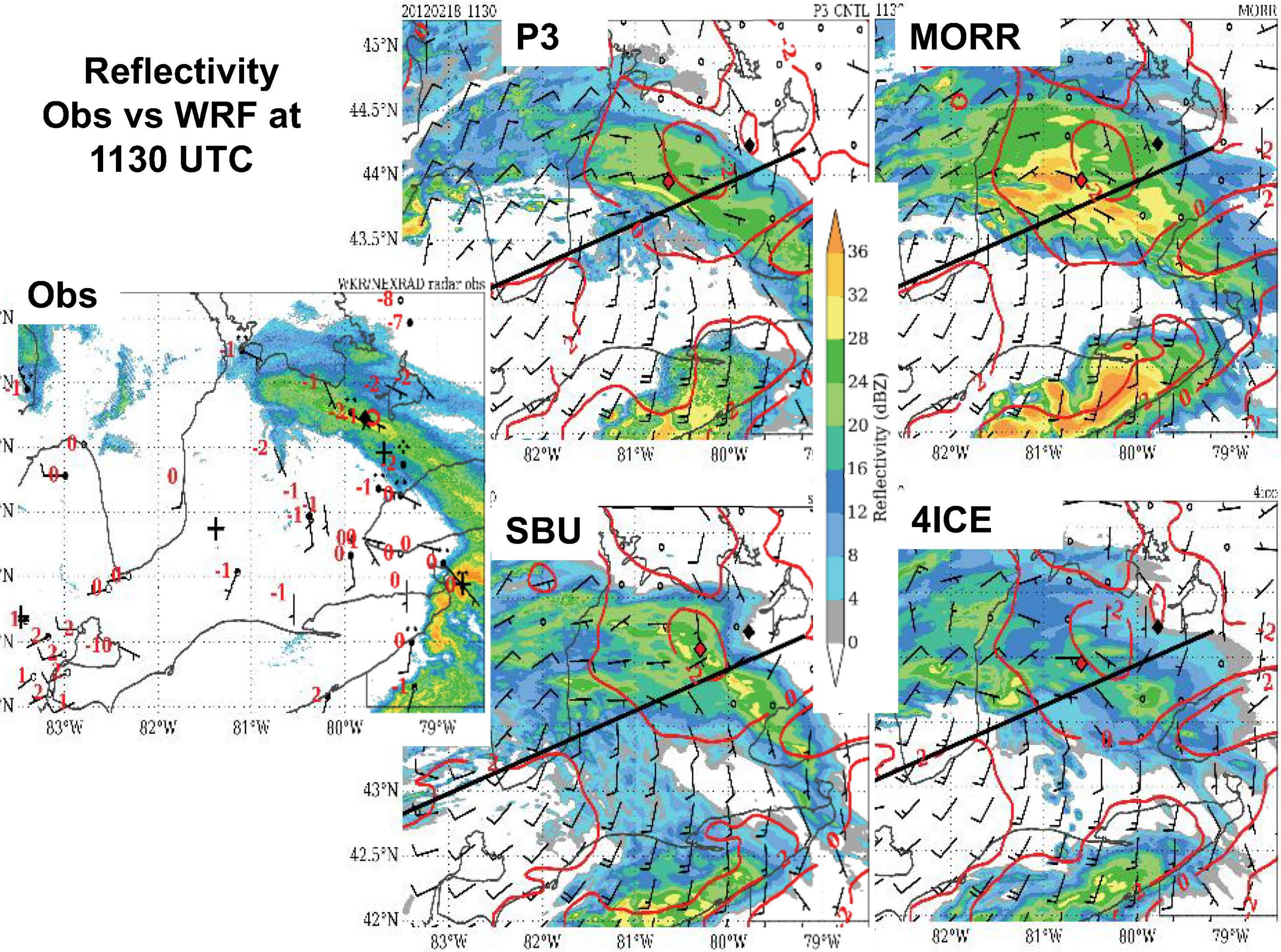

0700 UTC -- Genesis
0900 UTC – Early Mature
1100 UTC – Mature
OBS
Reflectivity (dBZ)
20120218 0700
20120218 0900
20120218 1100
P3 CNTL
45°N
44.5°N
44°N
43.5°N
43°N
42.5°N
42°N
83°W
80°W
79°W
WRF-P3: 10-m winds; 2-m Temp (red)

WRF Microphysical Schemes

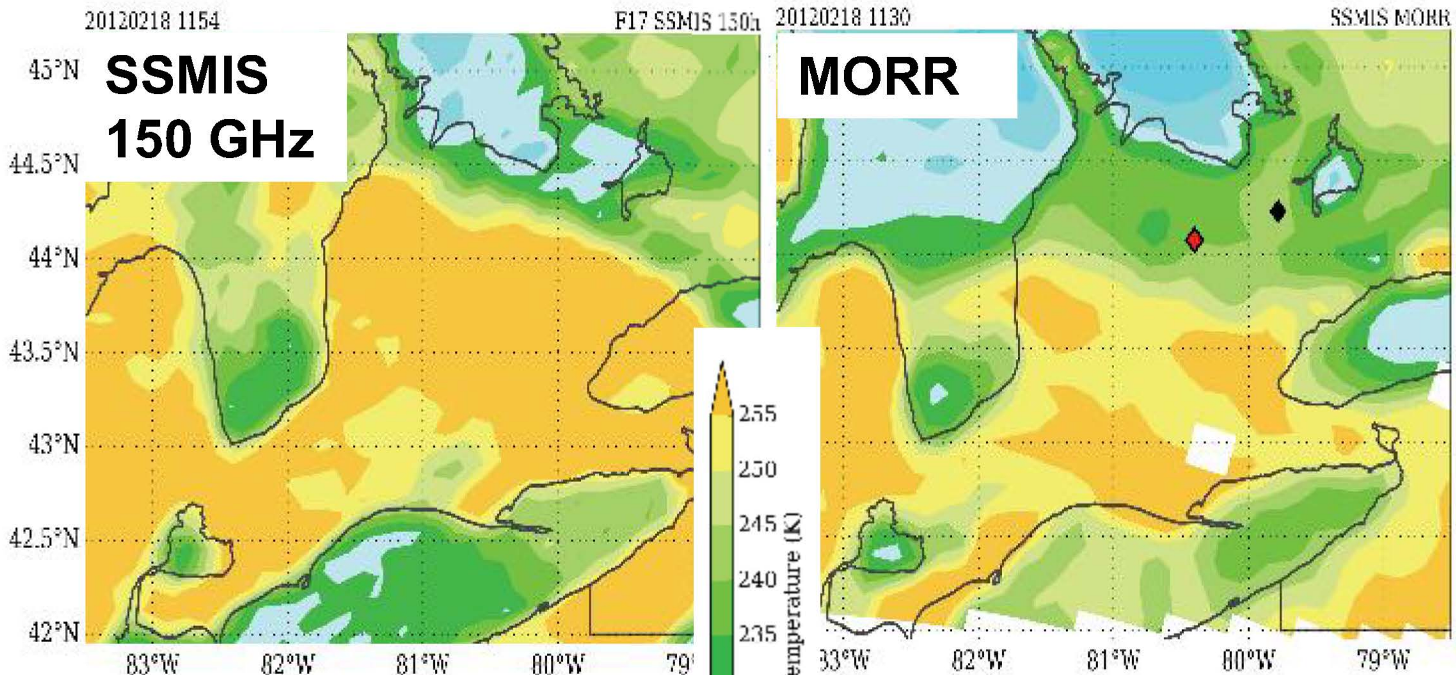
Scheme / Acronym	Moments	Notes	Selected References
Predicted Particle Properties / P3	2	Single ice-phase category evolves freely in time and space; lookup table for N_{os}, λ_s based on mass and number concentration	Morrison et al. (2015a) Morrison et al. (2015b)
Morrison / MORR	2	Explicit prediction of number concentration and mass for each species	Morrison et al. (2009)
Goddard 4ICE / 4ICE	1	Snow mapping routine for $N_{os}(T,q_s)$ and $N_{og}(T,q_g)$	Lang et al. (2014)
Stony Brook / SBU	1	$N_{os}(T)$ by Houze et al. (1979); M-D and V-D functions of diagnosed riming factor Ri, T	Lin and Colle (2011) Lin et al. (2011)

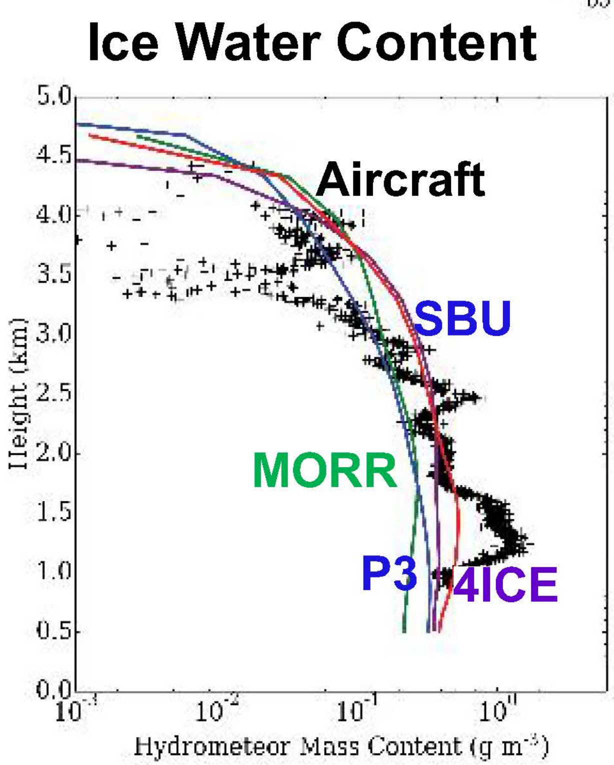
Scheme	N_{os} (m^{-4})	μ_s	ρ_s (kg m^{-3})	a_m (kg m^{-bm})	b_m	a_v (m^{1-bv} s^{-1})	b_v
P3	$f(q_s, M_{0s})$	lookup table	predicted	$\frac{\pi}{6}\rho_S$	3	$f(R_e, X)$	$f(R_e, X)$
MORR	$f(M_{0s}, \lambda_s)$	0	100 / 400	$\frac{\pi}{6}\rho_S$	2	11.72 / 19.3	0.41 / 0.37
4ICE	$f(T, q_s)$	0	50 / 300, 500	$\frac{\pi}{6}\rho_S$	3	151.01 / 330.22, 544.83	0.24 / 0.36, 0.54
SBU	$f(T)$	0	$f(D)$	$f(T, R_i)$	$f(T, R_i)$	$f(T, R_i)$	$f(T, R_i)$

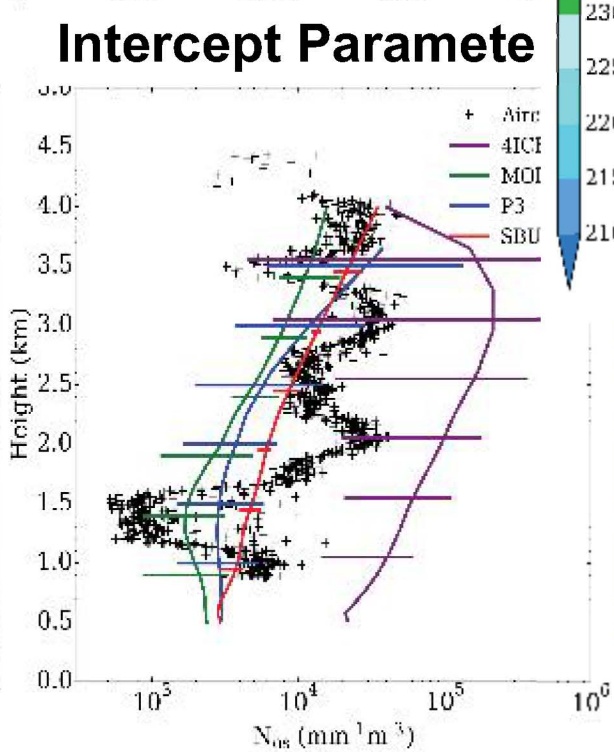
Reflectivity
Obs vs WRF at 1130 UTC

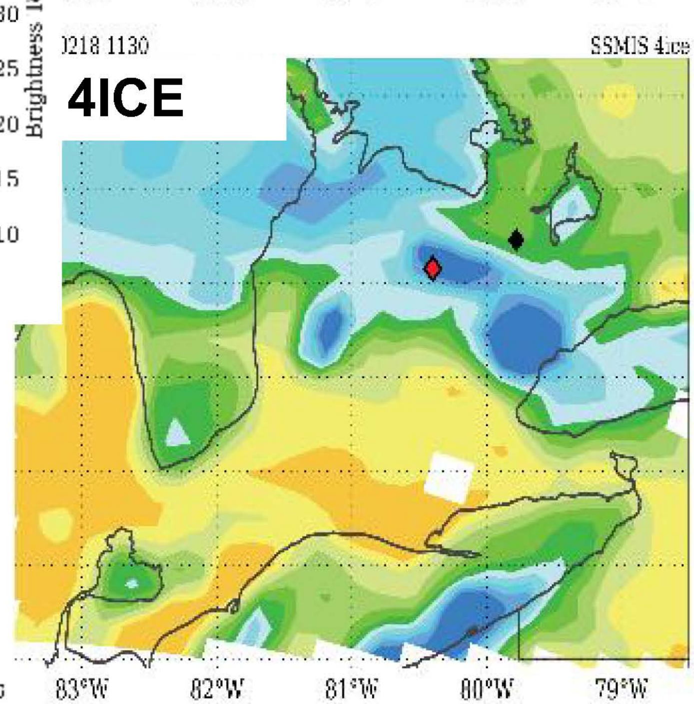


Satellite Simulator Comparisons with WRF Micro at 1130 UTC









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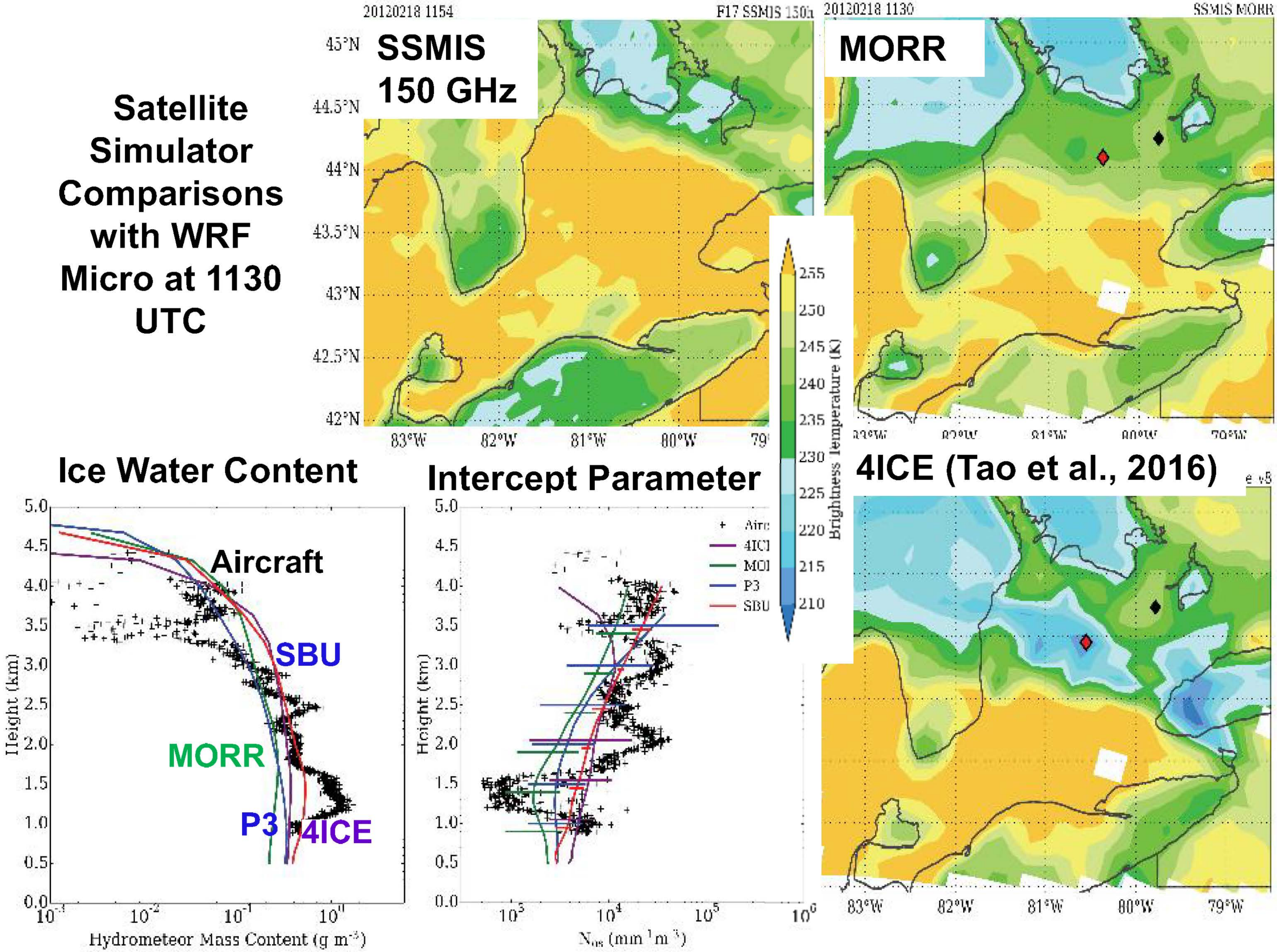
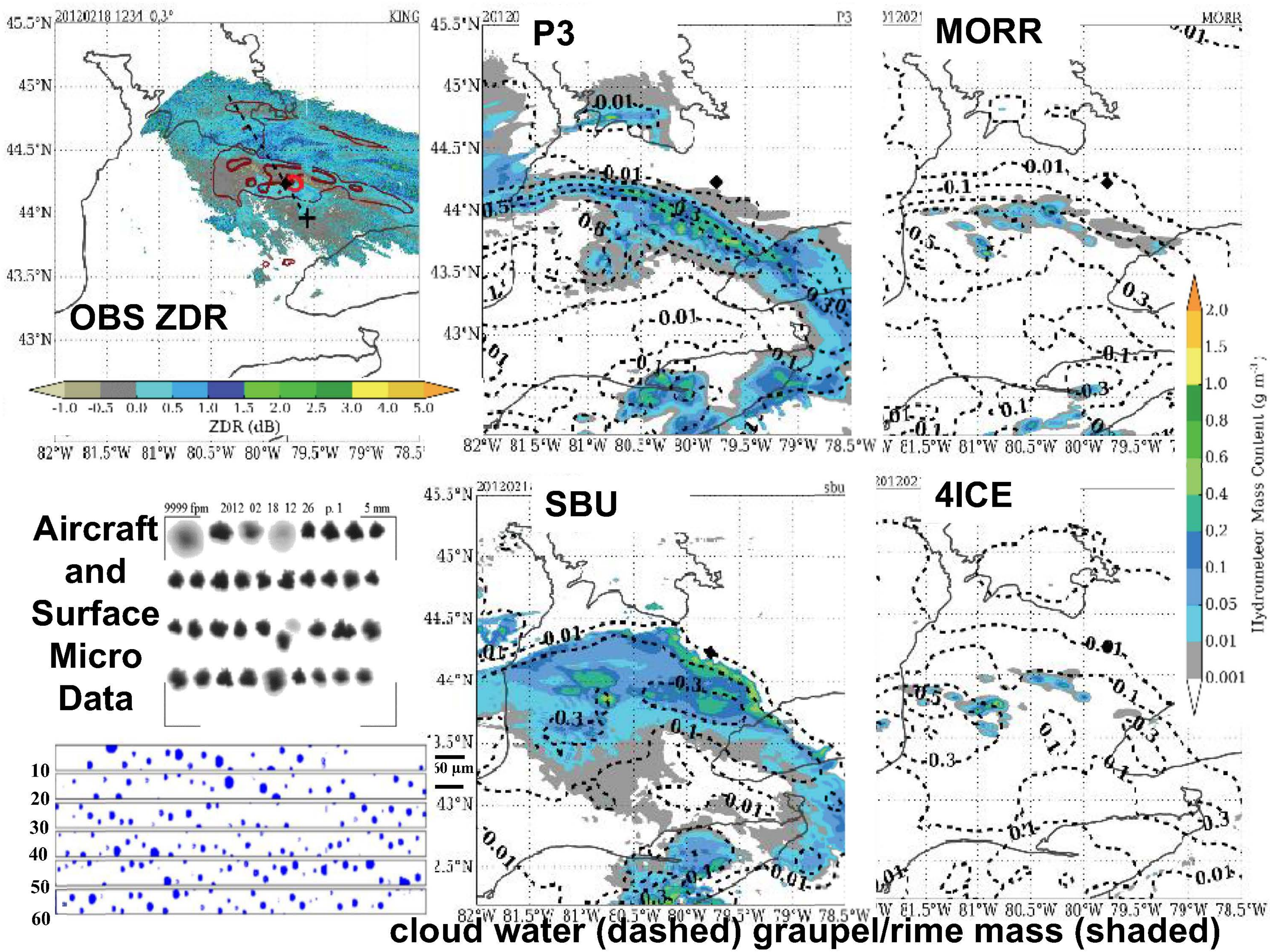
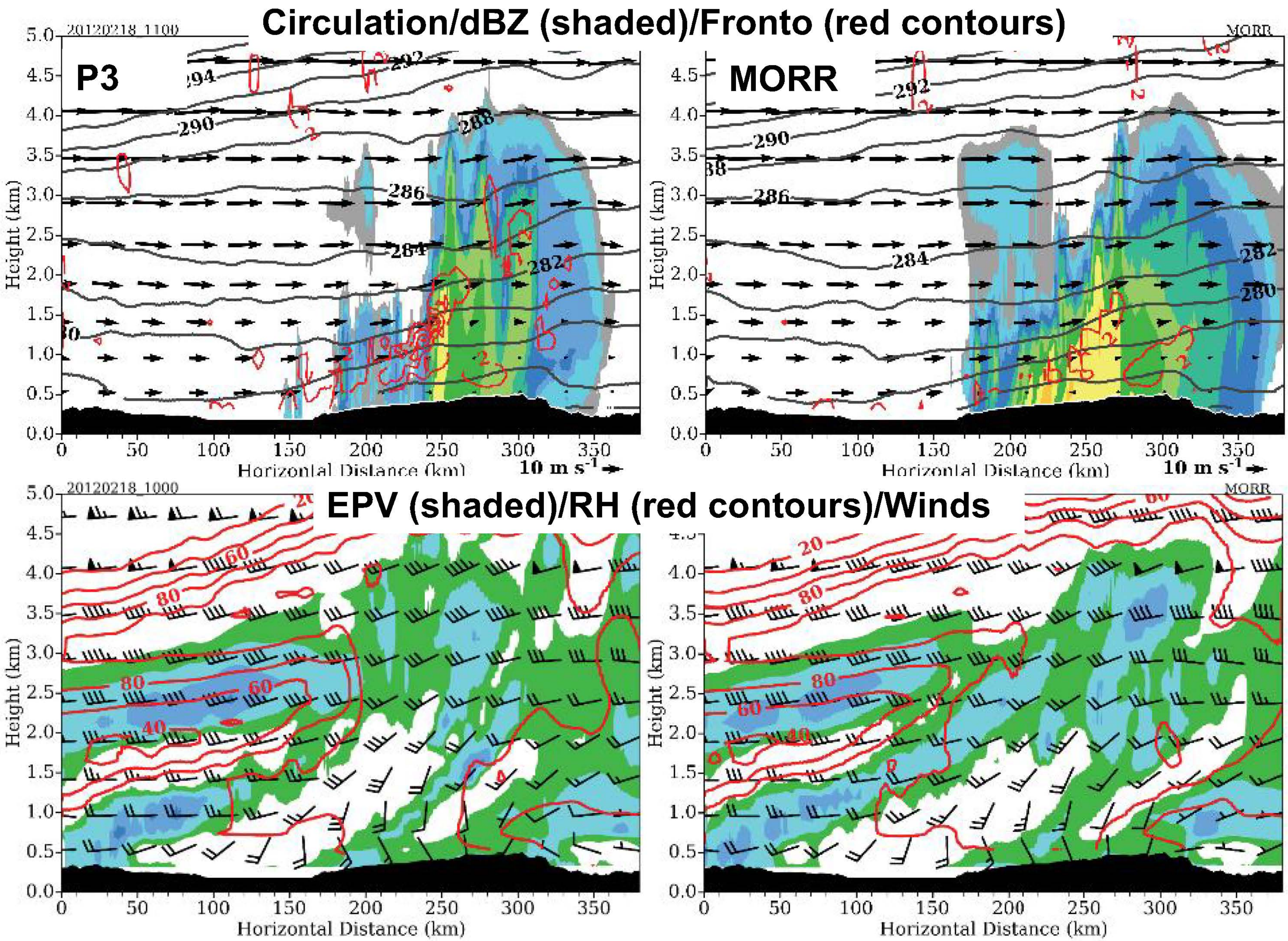
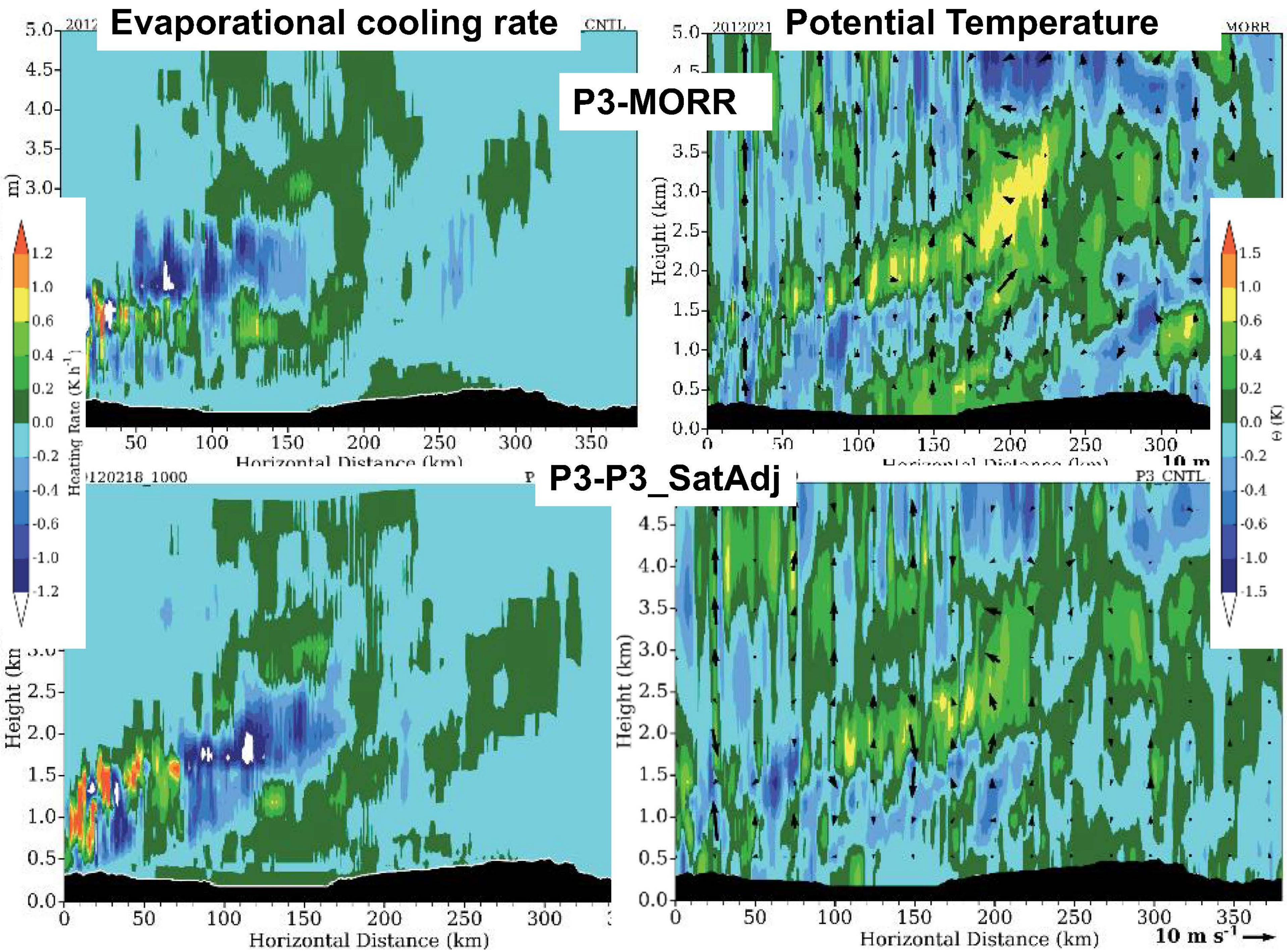




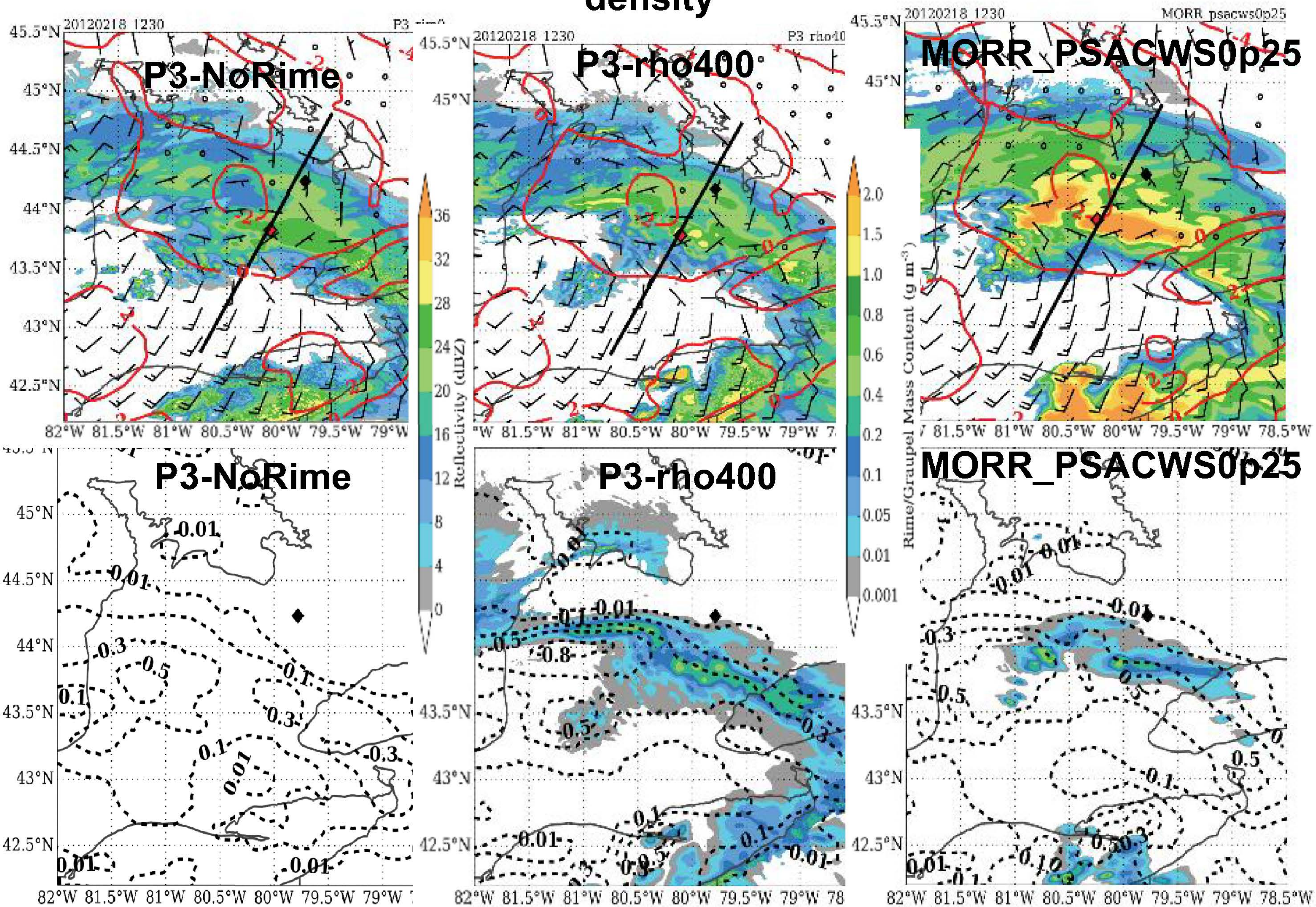
OBS ZDR
ZDR (dB)
P3
MORR
SBU
4ICE
Hydrometeor Mass Content (g m⁻³)
Aircraft and Surface Micro Data
cloud water (dashed) graupel/rime mass (shaded)


Circulation/dBZ (shaded)/Fronto (red contours)
20120218_1100
P3
MORR
Height (km)
Horizontal Distance (km)
10 m s-1
EPV (shaded)/RH (red contours)/Winds
20120218_1000
MORR
Height (km)
Horizontal Distance (km)



Evaporational cooling rate
Potential Temperature
P3-MORR
P3-P3_SatAdj
Heating Rate (K h^{-1})
θ (K)
Height (km)
Horizontal Distance (km)
10 m s^{-1}
CNTL
MORR
P3_CNTL

Importance of riming, MORR accretion threshold, less sensi to ice density



Conclusions

- Band genesis occurred with frontogenesis in the presence of weak potential and conditional instability feeding into the region.

- There was significant amounts of cloud water and riming within the rising (southern) branch of the frontal circulation.

- Saturation adjustment scheme led to a weaker, more disorganized band by causing an increase in mid-level stability feeding into the band and a decrease in low-level stability.

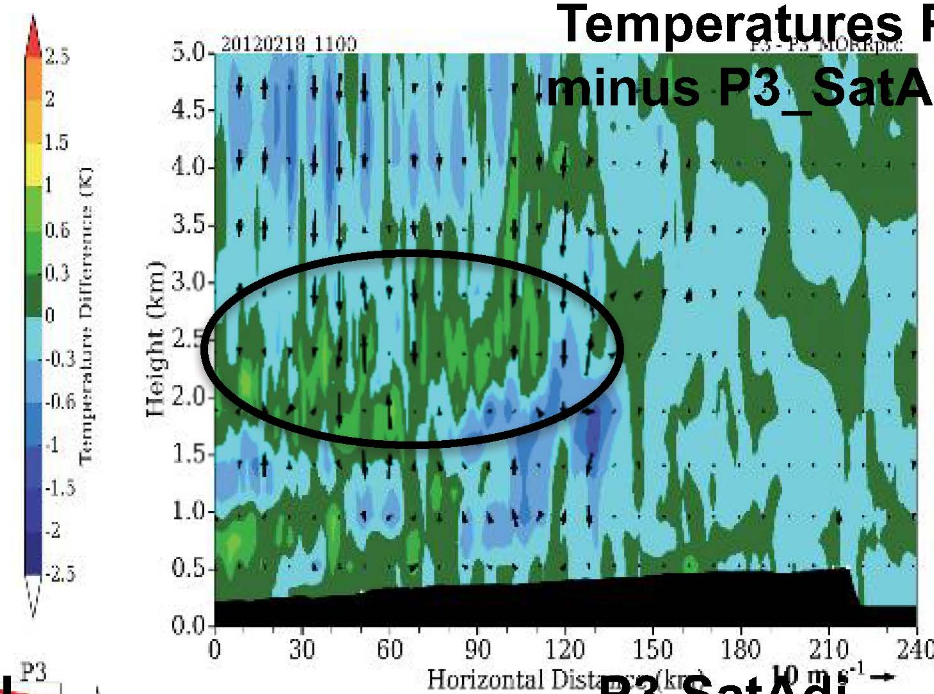
- Enhanced sublimation (dominant) and melting in lowest 1 km led to a reduction in the cross-frontal thermal gradient and a more gentle sloping frontal surface and weaker frontogenesis.

- Most of the differences are related to the way the schemes partition snow and graupel. The new P3 scheme with continuous dry ice/snow to rime/graupel was most realistic.

Supplement Slides

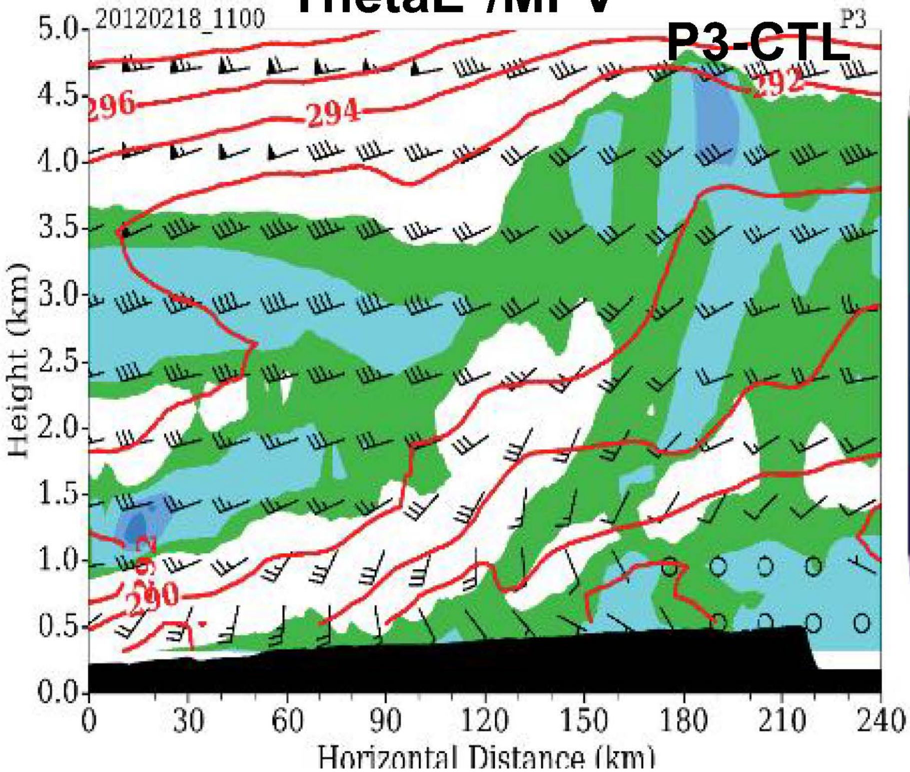
P3_MORRpcc has more low-level instability protruding into the band as a result of excessive evap cooling near cloud top (Grabowski and Morrison 2007)

Temperatures P3 minus P3_SatAdj

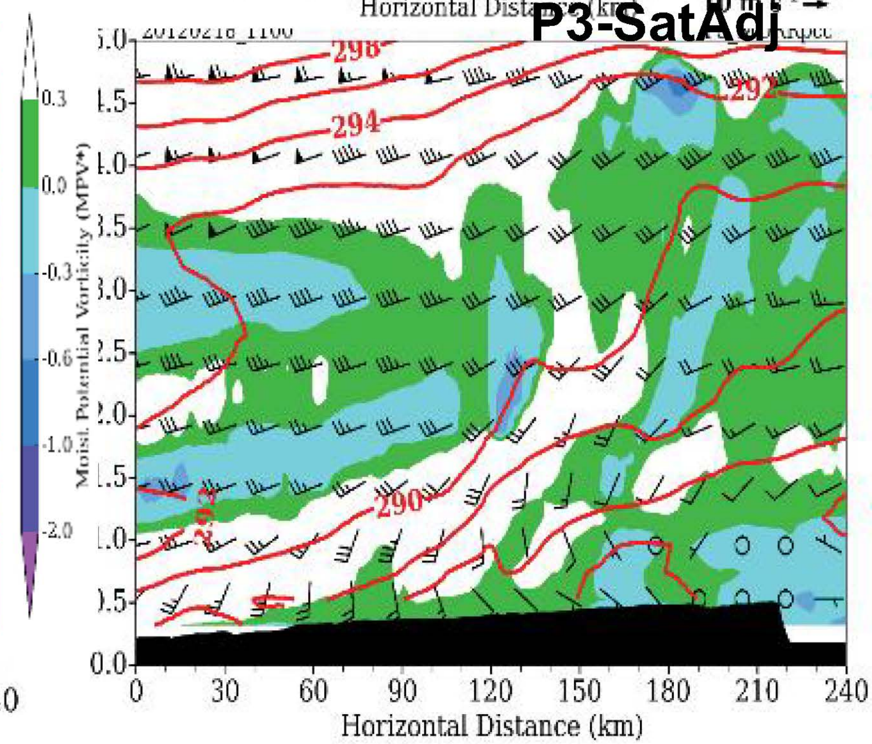


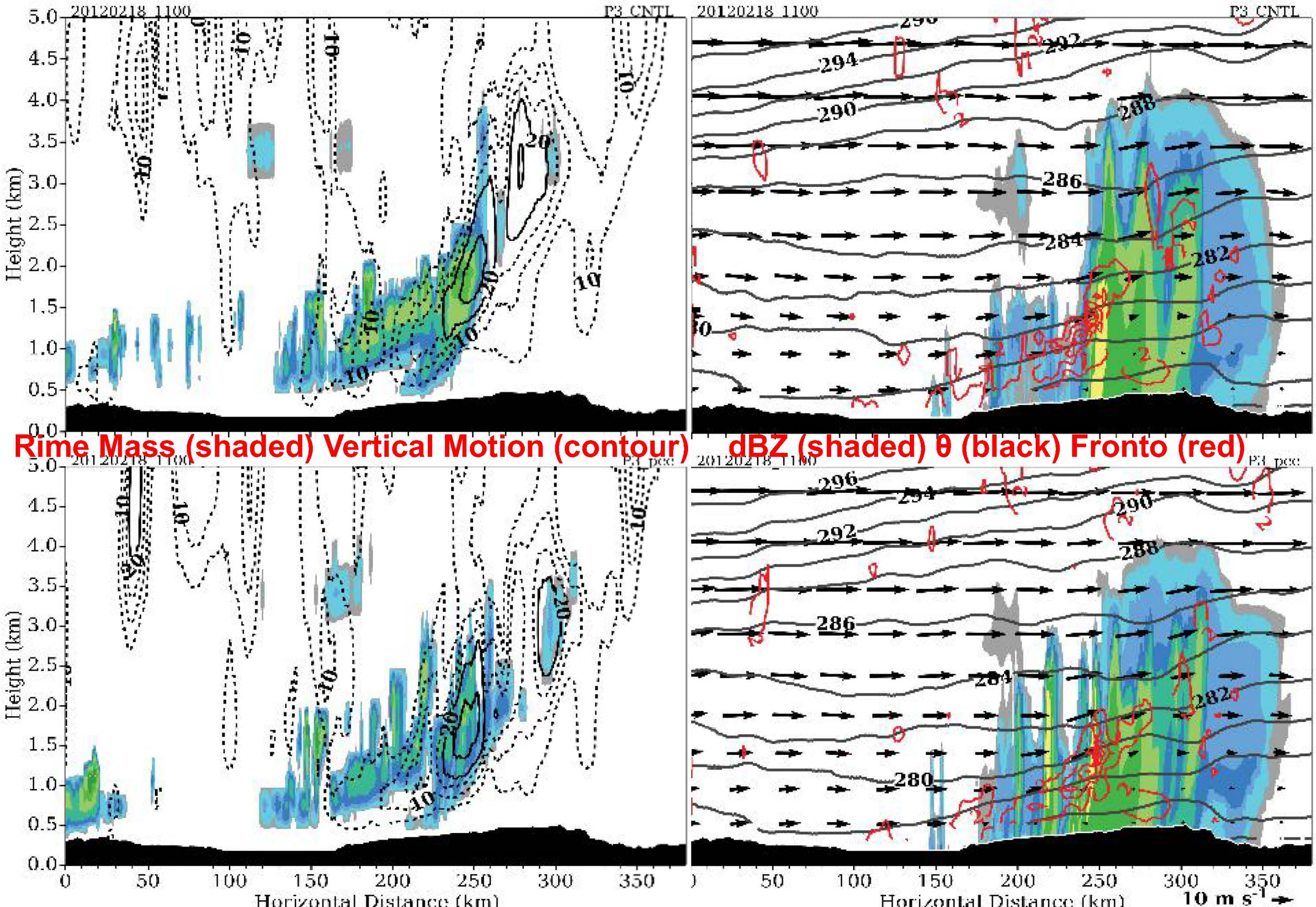
ThetaE*/MPV*

P3-CTL



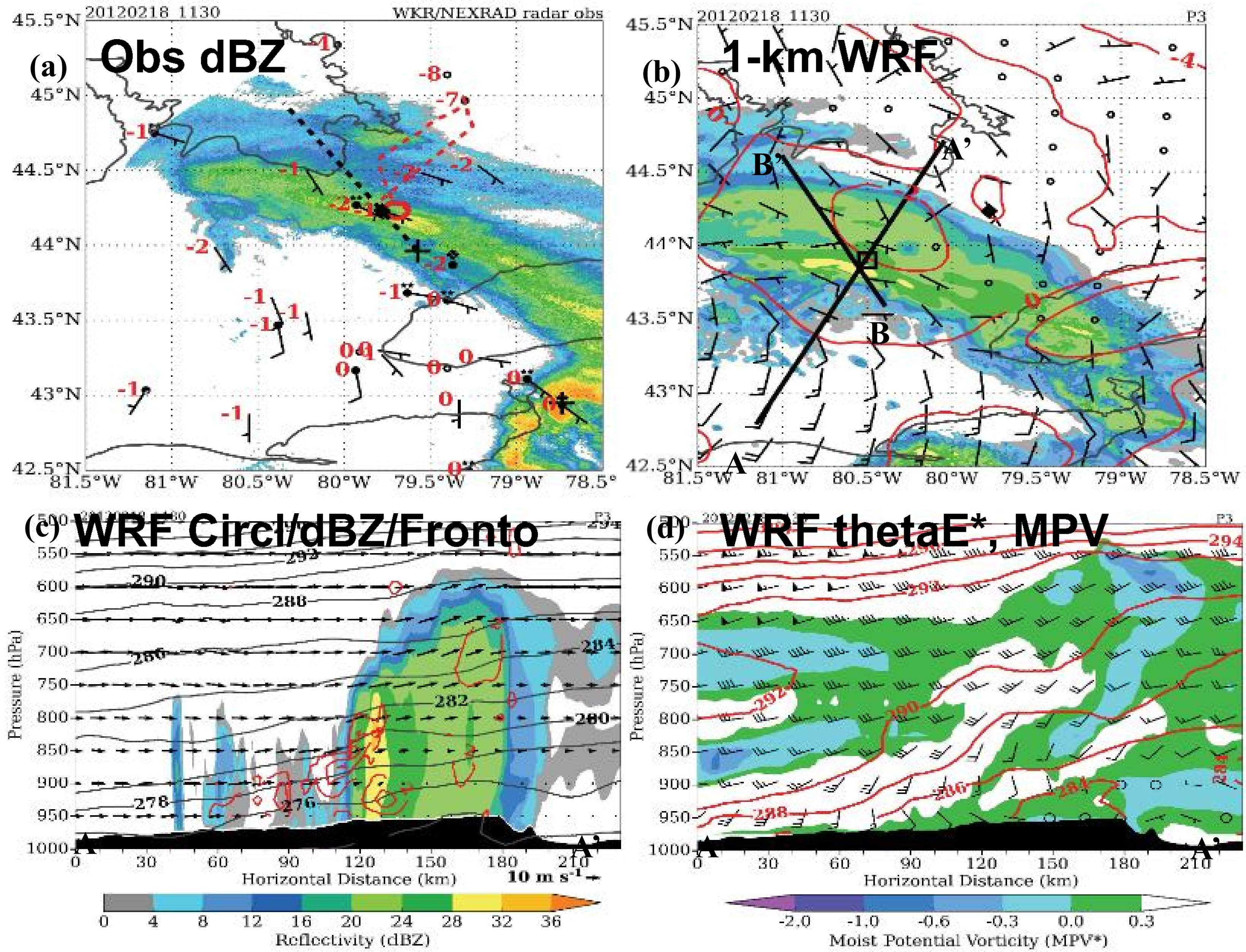
P3-SatAdj



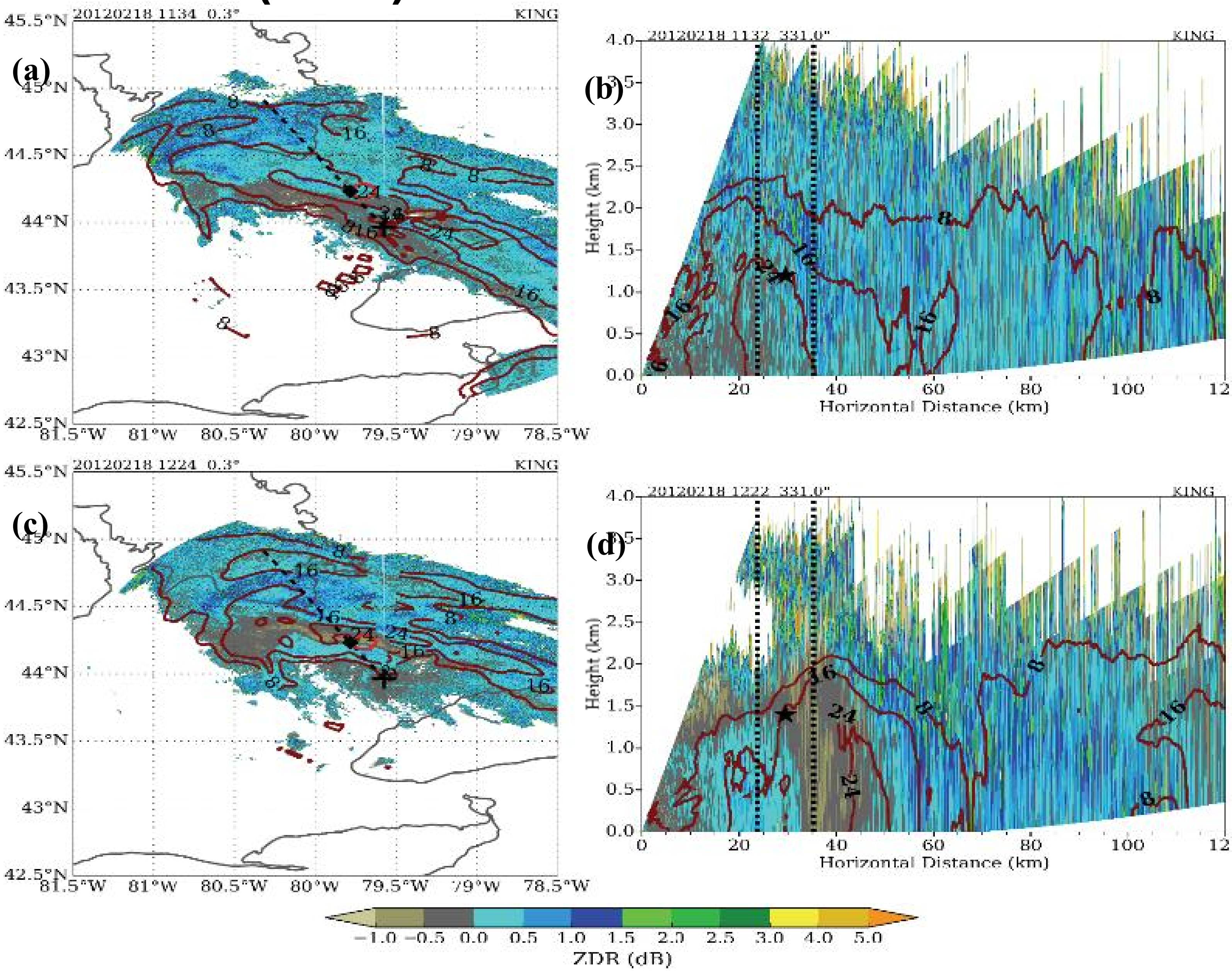


Saturation Adjustment in P3 leads to more convective plumes near band, less organized frontal band, less cloud water upstream (more evaporation)

Forcing and Stability for Frontal Band



Dual Pol (ZDR) Observations of Frontal Band



Ice Microphysics for North (top) v. South (bottom) part of Band